

# Incidence and Severity of Combat Hand Burns After All Army Activity Message

Travis L. Hedman, PT, DPT, OCS, Evan M. Renz, MD, FACS, Reginald L. Richard, MS, PT, Charles D. Quick, OTR/L, William S. Dewey, PT, CHT, OCS, David J. Barillo, MD, FACS, Leopoldo C. Cancio, MD, FACS, David G. Baer, PhD, Steven E. Wolf, MD, FACS, and COL John B. Holcomb, MC

**Background:** Operations Enduring Freedom and Iraqi Freedom have resulted in severe burns to the hands. Because of the frequency and severity of hand burns, an All Army Activity (ALARACT) message was distributed emphasizing the importance of hand protection (HP). Our purpose was to assess the effectiveness of the ALARACT in reducing the incidence and severity of hand burns.

**Methods:** A retrospective review of the US Army Institute of Surgical Research Burn Registry for active duty personnel with hand burns 17 months before and after the ALARACT was conducted. Data include percentage total body surface area (% TBSA), % full-

thickness injury, depth of hand burn, and ratio of hand burn to TBSA. Statistical analysis was performed using Mann-Whitney *U* test.

**Results:** Four hundred fifty-one military personnel were admitted during the 34-month period: 257 (56.9%) pre-ALARACT; 194 (43.1%) post-ALARACT. Two hundred thirty-nine (52.9%) sustained hand burns: 138 (53.7%) pre-ALARACT; 101 (52.1%) post-ALARACT ( $p = \text{NS}$ ). Mean TBSA: 21.5% pre-ALARACT; 28.8% post-ALARACT ( $p = 0.01$ ). Mean full-thickness TBSA: 14.5% pre-ALARACT; 21.9% post-ALARACT ( $p = 0.02$ ). Mean hand TBSA: 3.2% pre-ALARACT; 3.2% post-ALARACT ( $p = \text{NS}$ ). Mean ratio, hand burn to TBSA:

36% pre-ALARACT; 25% post-ALARACT ( $p < 0.001$ ).

**Discussion:** Post-ALARACT, the incidence of hand burns remained unchanged. Despite an increase in burn severity, ratio of hand burn to TBSA decreased, suggesting a possible relationship between increased awareness and use of HP and decreased injury. Based on the data collected, the impact of the ALARACT is unclear. The importance of HP remains a priority. The fact that the incidence of hand burns remains unchanged demands our continued awareness and increased efforts.

**Key Words:** Hand burns, Prevention, Incidence, Military, ALARACT.

*J Trauma.* 2008;64:S169–S173.

Historically, severe burns account for between 5% and 20% of combat casualties.<sup>1–5</sup> All US military service members who sustain burns requiring care at a burn center are transported to the United States Army Institute of Surgical Research Burn Center (USAISR), the sole Department of Defense Burn Center, in San Antonio, TX.<sup>1,5–7</sup> Previous work from this institute reported that burns from Operations Enduring Freedom/Iraqi Freedom (OEF/OIF) account for approximately 5% of combat casualties.<sup>5</sup> Two recent reports documented that the hands and face are the most frequent areas burned in OEF/OIF combat.<sup>5,8</sup> Kauvar et al.<sup>5</sup> reported on 142 combat casualties, of which 80% sustained burns to the hands and 77% to the head.

Isolated hand and head burns accounted for 15% of casualties, whereas hand burns alone accounted for 6%.<sup>5</sup> Casualties with hand burns sustained injury to >50% of the at-risk surface area of the hands (Fig. 1).<sup>5</sup> Additionally, the severity of burns has increased in overall total body surface area (TBSA) and full-thickness (FT) involvement (Fig. 2).<sup>5,8</sup> Kauvar et al.<sup>8</sup> also reported that the hand was the most frequently burned body area, accounting for 76% of 171 combat casualties. In this study cohort, isolated hand and head burns accounted for 11% of admissions, whereas hand burns alone accounted for 8% of admissions.<sup>8</sup>

The predominance of injury to the hands and head is not new and has been reported throughout recent military history. Eldad and Torem reported on casualties from the Lebanese War during 1982. More than 75% of burn casualties from this conflict sustained burns to the hands and face when unprotected.<sup>9</sup> Although the combined surface area of both hands comprises only approximately 5% of TBSA, the resulting long-term functional impairment can be substantial.<sup>5,10–12</sup> As a result of the high incidence of hand burns and the tremendous morbidity associated with them, efforts to reduce the severity and potentially prevent burns to the hands have been described.<sup>5,13,14</sup>

The use of protective garments and specialized clothing to reduce the incidence and severity of burns has been documented.<sup>9,13–15</sup> A broad and consistent use of protective garments has been advocated.<sup>5,9</sup> The use of fire-

Submitted for publication October 30, 2007.

Accepted for publication October 31, 2007.

Copyright © 2008 by Lippincott Williams & Wilkins

From the United States Army Institute of Surgical Research, Burn Center, Fort Sam Houston, Texas.

Presented at the 2007 Advanced Technology Applications for Combat Casualty Care conference.

The opinions or assertions contained herein are the private views of the authors, and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

Address for reprints: Travis Hedman, PT, DPT, OCS, USAISR Army Burn Center, 3400 Rawley E. Chambers Avenue, Fort Sam Houston, TX 78234; email: travis.hedman@amedd.army.mil.

DOI: 10.1097/TA.0b013e318160ba0c

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE <b>OCT 2007</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2007 to 00-00-2007</b>	
4. TITLE AND SUBTITLE <b>Incidence and Severity of Combat Hand Burns After All Army Activity Message</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>U.S. Army Institute of Surgical Research (USAISR),3400 Rawley E. Chambers Avenue,Fort Sam Houston ,TX,78234-6315</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>Same as Report (SAR)</b>	18. NUMBER OF PAGES <b>5</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			



**Fig. 1.** Hand burn sustained to 50% of at-risk BSA.



**Fig. 2.** Full-thickness hand burn to 100% BSA requiring escharotomy.

retardant suits by pilots and armored vehicle crewman has reduced the incidence and severity of burns associated with combat operations.<sup>13,15</sup> Eldad and Torem<sup>9</sup> reported that the use of flame-retardant gloves alone reduced the incidence of hand burns from 75% to 7% among tank crewmen who sustained burns.

Because of the incidence and severity of OEF/OIF hand burns treated at the USAISR Burn Center previously reported,<sup>5</sup> an All Army Activity (ALARACT) message was distributed to Army leaders in December 2005 to emphasize the importance of wearing fire-resistant (FR) rated (Nomex or Kevlar; DuPont, Wilmington, DE) hand protection (HP).<sup>16</sup> The purpose of this study was to assess the effectiveness of the ALARACT, and any resulting changes in policy, in reducing the incidence and severity of hand burns sustained by warriors in the current war.

## MATERIALS AND METHODS

The USAISR burn center prospectively maintains a registry containing demographic, injury characteristic, and outcome information of the burns in military and civilian

patients. Utilizing a Brooke Army Medical Center/USAISR Institutional Review Board approved protocol, a retrospective review of the USAISR Burn Registry data of active duty personnel who sustained combat-related hand burns from August 2004 to December 2005 and January 2006 to May 2007 (17 months before and after the issuance of the ALARACT) was performed. Demographic information, injury severity, and characteristics of burn were recorded. A study database was created in Excel (Microsoft, Redmond, WA). Chi-square and Mann-Whitney *U* statistical analyses were performed on all data for the two groups using Sigma Stat 3.1 (Systat, San Jose, CA). Data are presented as mean  $\pm$  SD. The ratio of total hand burn to total TBSA was calculated for effect.

Data were available only for those patients with burns requiring admission to the USAISR burn center. Data were unavailable for patients treated for minor, superficial (hand/TBSA) burns in theater, and returned to duty without evacuation. Data were also unavailable for service members exposed to, but not sustaining, a thermal injury as a result of use of HP.

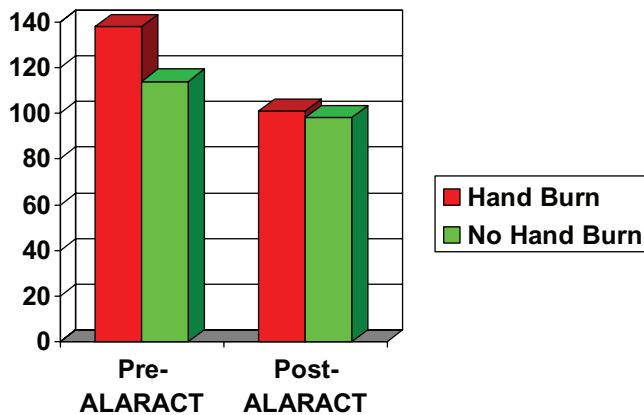
## RESULTS

A total of 451 military personnel were admitted to the USAISR burn center during the 34-month study period as a result of combat operations. Of these, 252 patients (55.8%) were pre-ALARACT, 199 patients (44.2%) were post-ALARACT. Two hundred thirty-nine patients (52.9%) overall sustained hand burns whereas 212 (47.1%) did not. Of the 239 patients admitted with hand burns, 138 (57.7%) were before the ALARACT and 101 (42.3%) after ( $p = \text{NS}$ ). Of the 212 patients admitted without hand burns, 114 (53.7%) were before and 98 (46.3%) were after the message ( $p = \text{NS}$ ) (Fig. 3). The mean TBSA pre-ALARACT was 21.5% ( $\pm 23.1$ ) compared with 28.8% ( $\pm 24.8$ ) post-ALARACT ( $p = 0.01$ ). The mean total FT TBSA involvement was 14.5% ( $\pm 22.3$ ) and 21.9% ( $\pm 24.6$ ) before and after the ALARACT, respectively ( $p = 0.02$ ). The mean total hand TBSA involvement was 3.2% ( $\pm 1.4$ ) before and 3.2% ( $\pm 1.5$ ) after the ALARACT ( $p = \text{NS}$ ). The mean ratio of hand burn compared with total TBSA was 36% ( $\pm 29.4$ ) pre-ALARACT to 25% ( $\pm 26.7$ ) post-ALARACT ( $p < 0.001$ ). Results are summarized in Table 1.

## DISCUSSION

The problem of hand burns sustained in OEF/OIF operations is significant. Previous reports demonstrate the incidence of hand burns among combat casualties as high as 80%.<sup>5,8</sup> Burns to the hands are one of the most difficult areas to care for and rehabilitate, often leading to significant long-term morbidity and functional consequences (Fig. 4).<sup>5,10-12</sup> The only reliable way to reduce the impact of hand burns is to prevent the injuries themselves (Fig. 5).<sup>5</sup> This report examined the problem as it relates to the use of protective garments.

After the ALARACT in December 2005, the total TBSA and total FT involvement significantly increased indicating a



**Fig. 3.** Comparison of incidence of hand burns pre- with post-ALARACT.

greater degree of injury severity post-ALARACT. However, the incidence and severity of hand burns remained unchanged (Table 1). Thus, our collective efforts to date to decrease the impact of hand burns through prevention do not seem to be successful. If the ALARACT had the intended effect, one would expect to see a decrease in either the incidence or severity of hand burns. Improving the implementation of the guidance to wear HP may be challenging. These challenges include the numerous threats to life and limb on the battlefield, which compete for attention with hand burns, the potential impact HP has on dexterity and heat dissipation, and the transient nature of the at-risk population. To achieve success in this endeavor, we must reevaluate our approach to this problem and determine what can be improved.

First, the essence of an ALARACT message is to inform military leaders of an identified issue and resolution. This information must be disseminated throughout to all units in theater. Confounding this is the process of unit mobilization in and out of theater, providing an opportunity for information to be lost. We have no data with regard to dissemination of the message to the at-risk population. Such information may be difficult to obtain given the operational environment. Second, for the intended effect to occur, changes in the global approach to the problem must occur to include issuance of HP, training on use of HP, and enforcement of use of HP. Through the dedicated efforts of PEO Soldier and its affiliates, the Army alone has issued more than 1.93 million pair of FR-rated gloves to warriors. However, simply because

gloves were issued does not guarantee use. Conversely, if warriors are wearing non-FR rated HP, there seems to be little benefit and perhaps leads to a false sense of security. Despite the Army's best efforts to ensure that every soldier has HP available to them, factors such as temperature, timing, and individual decisions still plague the forces. Third, HP must be functional to allow service members to perform tactical operations necessary to complete the mission. Compliance with use of HP could potentially be decreased if the equipment impedes tactical operations. Despite these challenges, efforts to improve compliance with use of HP may yield the improvements we seek.

It should be noted that the true impact of the ALARACT may not be reflected in the injury data. If a service member escaped serious injury as a result of glove use, then this person would not arrive at the USAISR burn center for care. Our data set included only those service members who sustained burn injuries to the hands requiring evacuation to the USAISR. Data on those service members not admitted to our burn center must be collected and reviewed to analyze the full impact of the ALARACT.

Despite an increase in overall burn severity post-ALARACT, it is noteworthy that the ratio of total hand burn to total TBSA decreased. This finding suggests that there may have been some beneficial effect of increased awareness and use of HP; however, the evidence was masked by an overall increase in burn severity. Logically, one would expect that if the injuries sustained by service members post-ALARACT were more severe, as indicated by an increase in total TBSA and total FT TBSA involvement, the severity of hand injuries would have been greater pre- to post-ALARACT. However, our data demonstrate that severity of hand injury did not change. Additionally, examination of the data set for isolated hand burns only revealed a non-significantly different incidence of 9% and 7% before and after the ALARACT. These results suggest that some level of protection has been provided to hands post-ALARACT.

Based on the data collected thus far, the exact impact of the ALARACT is unclear; however, HP remains a priority. The fact that the overall incidence of severe hand burns remains unchanged during the past 3 years demands our continued awareness and increased effort to reduce this type of injury. These efforts need to address the challenges of the operational environment. Assessment of the current threat among the at-risk population as well as review of the

**Table 1** Comparison of Hand Burn Groups

Timeline	N	Incidence HB	Mean TBSA (SD)	Mean FT (SD)	Mean HB BSA (SD)	Mean HBPT (SD)	Mean HBFT (SD)	Mean HB:TBSA (SD)
Pre-ALARACT	138	57.7%	21.5% (23.1)	14.5% (22.3)	3.2% (1.4)	1.4% (1.3)	1.8% (2.1)	36% (29.4)
Post-ALARACT	101	42.3%	28.8% (24.8)	21.9% (24.6)	3.2% (1.5)	1.2% (1.4)	1.9% (1.9)	25% (26.7)
p	NS	NS	0.01	0.02	NS	NS	NS	<0.001

N indicates number of hand burns; HB, hand burn; HBPT, hand burn partial-thickness; HBFT, hand burn full-thickness; NS, not significant; SD, standard deviation.





**Fig. 4.** Hand with significant long-term impairment and disability after burn.



**Fig. 5.** Prevention of hand burn through use of appropriate protective gloves.

use of the available protective equipment is warranted. Leaders must ensure warriors are issued and wear approved HP. Additional efforts to ensure that intervention efforts are repeated as new personnel arrive will be crucial in improving the protection of military service members. Further collection and analysis of outcome data are essential in finding new solutions to this problem.

## ACKNOWLEDGMENTS

We extend our greatest appreciation to Mrs. Jodi L. Ennis, RN, BSN, without whose support, this project would not have been possible. We also acknowledge the endless sacrifices of US military personnel worldwide.

## REFERENCES

1. Cancio LC, Horvath EE, Barillo DJ, et al. Burn support for Operation Iraqi Freedom and related operations, 2003 to 2004. *J Burn Care Rehabil.* 2005;26:151–161.
2. Champion HR, Bellamy RF, Roberts P, et al. A profile of combat injury. *J Trauma.* 2003;54:S13–S19.
3. Sidel'nikov VO, Paramonov BA, Tatarin SN. Medical care for the burnt in modern local military conflicts. *Voen Med Zh.* 2002;323:35–39.
4. Shafir R, Nili E, Kedem R. Burn Injury and prevention in the Lebanon War, 1982. *Isr J Med Sci.* 1984;20:311–313.
5. Kauvar DS, Wolf SE, Wade CE, et al. Burns sustained in combat explosions in Operations Iraqi and Enduring Freedom. *Burns.* 2006;32:853–857.
6. Wolf SE, Kauvar DS, Wade CE, et al. Comparison between civilian burns and combat burns from Operation Iraqi Freedom and Operation Enduring Freedom. *Ann Surg.* 2006;243:786–795.
7. Kirksey TD, Dowling JA, Pruitt BA Jr, et al. Safe expeditious transport of the seriously burned patient. *Arch Surg.* 1968;96:790–794.
8. Kauvar DS, Cancio LC, Wolf SE, et al. Comparison of combat and non-combat burns from ongoing U.S. military operations. *J Surg Res.* 2006;132:195–200.
9. Eldad A, Torem M. Burns in the Lebanon War 1982: “the blow and the cure”. *Mil Med.* 1990;155:130–132.
10. van Zuijlen PP, Kreis RW, Vloemans AF, et al. The prognostic factors regarding long-term functional outcome of full-thickness hand burns. *Burns.* 1999;25:709–714.
11. Barillo DJ, Harvey KD, Hobbs CL, et al. Prospective outcome analysis of a protocol for the surgical and rehabilitative management of burns to the hands. *Plast Reconstr Surg.* 1997;100:1442–1451.
12. Serghiou MA, Holmes CL, McCauley RL. A survey of current rehabilitation trends for burn injuries to the head and neck. *J Burn Care Rehabil.* 2004;25:514–518.
13. Voisine JJ, Albano JP. Reduction and mitigation of thermal injuries: what can be done? *Mil Med.* 1996;161:54–57.
14. Baycar RS, Aker F, Serowski A. Burn casualties in combat: a need for protective garments. *Mil Med.* 1983;148:281–282.
15. Dougherty PJ. Armored vehicle crew casualties. *Mil Med.* 1990;155:417–420.
16. All Army Activity (ALARACT) Message 261/2005. High incidence of hand burns. Office of the U.S. Army Surgeon General. December 2005.

## DISCUSSION

**Dr. Donald H. Jenkins** (Wilford Hall Medical Center, San Antonio, TX): In this article by Hedman et al., the authors set out to show the relationship between hand burn incidence in current combat operations and hand protection (HP) in two time periods; before and after an ALARACT emphasizing the need for HP. Using the Burn Registry at the Institute of Surgical Research (ISR), a retrospective review was accomplished for these two time periods, which showed no difference in hand burn incidence although mean body surface area (BSA) burn and area of full-thickness burn went up. Interestingly, the mean ratio of hand burn to total body surface area burn decreased significantly.

Hand burns are particularly problematic, especially in military members, because of the great impact they have on the function of the burn victim. In fact, significant burns to the hands, <5% of the body surface area, will not only cause the injured soldier to be removed from the fight and from the theater, but quite possibly from the Army altogether. Nomex, a flame resistant aromatic nylon compound discovered in the 1970s, is the mainstay of personal protection from burns in the US military; from flight suits to gloves, the military issues them and they can mitigate or eliminate burn. There are, unfortunately, no standard requirements for typical ground forces, soldiers, and Marines to be issued or to wear such protective equipment.

During the last 5 years in the Global War on Terror, an increasing number of improvised explosive devices (IEDs), incendiary IEDs, and burns of larger size have been witnessed. Seeing the increasing number of soldiers returning from the war with isolated hand burns, the ISR provided a review of their registry data to the Office of the Surgeon General who, in turn, issued the ALARACT for the wear of Nomex gloves. Unfortunately, there is no way to tell how many soldiers received this, how many were actually issued gloves, or how frequently they were worn during combat operations.

That leads to the information and conclusions in this article. The authors have made no attempt to identify which, if any, of the hand-burn victims was wearing HP; they have assumed that hand burn equates with no protection worn. This assumption must be taken into account related to the finding of decreased hand involvement in burn injury distribution related to overall BSA burn. The authors do identify that their analysis is lacking a denominator to make it population-based and that those never burned as a result of wearing HP would be missed, but do not mention how many injured combatants who were either killed in action or died of wounds did and did not have hand burn injury. These important additional valuable data points would add further credibility to the findings in this article.

The use of personal protective equipment (PPE), from helmets to goggles, from body armor to flame resistant uniforms, is one of the few injury prevention strategies that can be used in combat. It seems that an attempt to introduce such a preventive strategy did not impact the incidence of hand burn using this ALARACT-method in the current conflict.

Further work, to include the addition of these important burn-mitigation PPE items to the Joint Theater Trauma Registry and better defining the role of this PPE in burn injury mitigation/prevention is required. This article has not closed the loop on this HP PPE initiative; it reveals further work is required to insure compliance with HP wear and more data of greater fidelity will be required to prove this injury prevention strategy works. Personal experience tells me that it does; the authors have to prove it.

**Dr. Travis Hedman** (US Army Institute of Surgical Research, Fort Sam Houston, TX): The services continue to procure and issue hundreds of thousands of pairs of approved fire-resistant (FR) gloves to warriors at risk. It is our observation that the Army, through programs such as PEO Soldier, is properly focused on identifying those at risk, and developing improved protective equipment, ensuring availability and encouraging compliance with use. Unfortunately, issuance of HP does not equate to use. Likewise, some soldiers elect to wear nonissued gloves that are not fire-resistant. The use of nonapproved HP seems to be of little benefit and may, in fact, provide a false sense of security.

Compliance in the use of FR gloves remains difficult to assess. Our initial efforts to identify which of the casualties with hand burns were wearing FR gloves confirmed the absolute need to collect data regarding glove use. We are currently developing a definitive survey tool for the purposes of collecting, reviewing, and analyzing data regarding the use of FR gloves.

We do agree that this study lacks the proper denominator to make it population based. Data regarding those warriors who did not sustain hand burns or sustained only superficial burns not requiring medical care because of wear of HP must be collected. However, including those warriors in the killed in action (KIA) or died of wounds (DOW) category may be misleading as these casualties often sustained burns in excess of 60% of their total body surface area and the hands were often involved. Future review and analysis of the Joint Theater Trauma Registry data may help us more clearly answer this question. We accept the challenge to provide our colleagues with the best evidence available and hope that the information can be used to help mitigate the severity of combat-related hand injuries related to burns.